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ABSTRACT

The purpose of this study is to examine how technology, namely virtual reality (VR), can be developed as a critical pedagogical tool. More specifically, the study explores whether the use of VR can challenge the traditional lecture format and make the classroom a more student-centered environment. In this instance, VR is defined as a set of multisensory, three-dimensional images generated by computer software, with which students can interact in real time. This study offers a theoretical grounding that examines how course instructors for one architectural history course used VR to present a more critical perspective about the Roman era and its urban design. This qualitative case study investigates one attempt to use VR technology as a way to re-conceptualize architectural history and create a more student-centered curriculum. The research question asks: How can VR technology be utilized to improve pedagogical practice? Student focus group protocol; professor interview protocol; and teaching assistant interview protocol are appended. (Contains 26 references.) (AEF)

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A New Roman World: Using Virtual Reality Technology as a Critical Teaching Tool

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Introduction

In the last decade, computer and Internet technology has become an increasingly mainstream component of higher education. By 1997, over 50% of college undergraduates used a computer at school (NCES, 1999). As electronic technology is now a part of daily life, educators increasingly consider the use of computers, the Internet and distance education as delivery tools for course content. Colleges tout their technological capabilities by indicating their Internet access speed and student-to-computer ratio. Lecture notes may be posted on-line and classes may have required discussions on electronic bulletin boards. However, while altering the presentation of course material, this technology may not actively transform the way knowledge is shared or learned. Furthermore, solely using technology as a delivery tool may fail to address varying students' needs and interests. It is possible that the validity and value of technology in the classroom can become ineffective because there is a lack of understanding regarding its true potential. A more sound rationale or more firm theoretical foundation is needed to understand better technology's pedagogical potential and link to practice.

The purpose of this study is to examine how technology, namely virtual reality (VR), can be developed as a critical pedagogical tool. More specifically, this study explores whether the use of VR can challenge the traditional lecture format and make the classroom a more student-centered environment. In this instance, VR is defined as a set of multisensory, three dimensional images generated by computer software, with which students can interact in real time (Sanders, 1997). This study offers a theoretical grounding that examines how course instructors for one architectural history course used VR to present a more critical

perspective about the Roman era and its urban design. This qualitative case study investigates one attempt to use VR technology as a way to reconceptualize architectural history and create a more student-centered curriculum. Our research question asks: How can VR technology be utilized to improve pedagogical practice?

Background

This case study focused on one architectural history course that used VR technology to demonstrate four computer-generated models (i.e. Temple of Saturn, Roman Forum, Roman Colosseum and Bascilica of Santa Maria Maggiore). These reconstructions were projected onto a 166-degree spherical screen and these images filled the peripheral vision. Movement through these virtual structures was simulated through computer controls that allowed viewers to "walk" through the building in real time or "fly" through from a bird's-eye perspective.

There were three course instructors, one professor and two teaching assistants. The professor who decided to pilot the VR technology was involved in the Rome Reborn Project, which is attempting to produce a VR model of ancient Rome. This opportunity allowed her to take some of these three-dimensional computer models and incorporate them in her architectural history class, with the goal of using these VR images to facilitate student learning. The two teaching assistants were doctoral students in architecture, who also had expertise in computer modeling. One teaching assistant's primary responsibility was to oversee the computer logistics and the other mainly worked with the enrolled students, assisting the professor with grading and student evaluations. However, all three instructors were involved with the preparation of the VR component of the course.

The forty undergraduate and graduate students had different reasons for enrolling in this architectural history course. The undergraduates primarily were taking the course for unit credit in an elective area because architecture is not an option as an academic major at this institution. Therefore, their curiosity and interest attracted them to the course material. For the graduate students, this particular class fulfilled a prerequisite in their course requirements. These students did not receive course credit and often took this class on top of their other first year requirements. Consequently, students entered this course with varying expectations and goals.

Literature Review

The subsequent literature review helps frame this exploratory study of how educational technology, specifically VR, may be used to promote student-centered learning. First, a brief overview of the definition and history related to VR will be discussed. Additional context about the use of VR in an educational setting will be presented. Finally, a summary of VR's strengths in an educational context will follow.

What is Virtual Reality?

While it appears that there is no single definition for VR, there are several shared characteristics common to this type of technology. First, VR aims to create a three-dimensional experience that seeks to simulate the sensation of being transported into a different space. In other words, the idea behind virtual reality is to deliver a sense of "being there" without actually having to travel to that place (Negroponte, 1995). This medium reacts to the user and does not just present one fixed point of view. Therefore, VR is presented as more than just a computer-created artificial environment.

VR also attempts to be multisensory and interactive. Rather than thinking about virtual reality in terms limited to its technological components, such as the computer hardware and software programs, virtual reality is seen for its experiential aspects (Steuer, 1992). Therefore, the emphasis is on the effect this technology has on the user. Use of headphones, 3-D glasses and motion-sensing gloves are all examples of how this sensory component can be achieved. Additionally, this technology seeks to allow simultaneous access to specific information and users also are prompted to "move" within the images, using the technology to feel like they are engaging with the constructed reality (Mitchell, 1995). Unlike pictures, photos or films, VR interacts with the individual, and its images reflect changes in user perspective and focus. Thus, one key characteristic of this technology is images that not only appear realistic to the user's senses but also provides a means for engagement or movement within the images.

Concepts related to VR have been around for quite some time (for more detailed history of VR see Littman, 1996; Pantelidis, 1993). Although the father of VR is generally credited to Ivan Sutherland, who first pioneered the idea of adding three-dimensional objects into real scenes (Helsel, 2000; Mitchell, 1995; Negroponte, 1995), fighter plane cockpit simulations were used as military training tools in the 1920s. The term "virtual reality" was first coined in the 1980s by Jaron Lanier to distinguish between traditional computer simulations and the increasingly immersive environments he was trying to develop for space exploration exercises (Sanders, 1997). However, the increased affordability of computers allowed for the more recent incorporation of VR in an entertainment, mass-market capacity, such as video games and motion picture films, which made this type of technology accessible to the general public.

Virtual Reality and Education

Finance and training issues in educational settings initially hindered institutional investment in this area of technology and consequently the use of VR in education did not begin in earnest until the 1990s (Siddens, 1999). While the use of VR has become an increasingly common technique in the sciences, the social sciences were slower to adopt these efforts. One of the first attempts to incorporate VR into the classroom occurred in 1991 at West Denton High School in New Castle-upon-Tyne, England (Clark, 1992). Three virtual environments were designed to engage students in developing awareness of dangerous work settings, gaining familiarity navigating through a foreign city and considering alternative uses of public space. This early effort was followed by the University of Washington in 1994, who built virtual worlds into a middle school curriculum on wetland ecology (Rose, 1995). Syracuse University also used VR in the mid-1990s linking various educational resources together (Siddens, 1999). Students were able to simulate flight over various regions of New York State as well as engage in virtual tours of national landmarks, such as Niagara Falls. Another example of the incorporation of VR for educational purposes emerged during the early 1990s in the for-profit sector through the creation of The Learning Sites, which continues to create archeological virtual worlds for educational purposes (Davis, 1997). As accessibility to computer technology increased, more institutions, including the University of Chicago, Carnegie Mellon and Ohio State University began to adapt aspects of VR as an educational tool (Helsel, 2000; Siddens, 1999).

Perceived Strengths of Virtual Reality

As use of VR in educational contexts expanded, so did efforts to assess its teaching and learning potential. Initial studies suggested that students do learn course material from

this type of delivery and that they express a high level of motivation because of the direct involvement in the learning experience (Sanders, 1997). Additionally, the use of VR appeared to help integrate course concepts together (Rose, 1995). Finally, immersion in the three-dimensional images created by VR seems to help students better contextualize the information presented.

The perceived educational benefits of VR technology is based on its ability to present information in a way that cannot be captured by traditional two-dimensional methods (Siddens, 1999). In other words, VR appears to provide a different perspective on the course material compared to books or slide projections because the information, especially buildings, can be placed in its context. By helping students examine the class information from various angles, students may develop a better understanding of the material presented. Additionally, this pictorial and interactive technology may provide another learning strategy for those who are visual or kinesthetic learners. Through this study, we are trying to determine whether any of the perceived strengths are experienced by the instructors and students.

Theoretical Framework

Having a theoretical framework can help guide our analysis and understanding of how VR could be used to help promote a more effective teaching-learning environment. In this section, the philosophy of constructivism will be paired with critical pedagogy as lenses that can guide the use of VR as a teaching tool.

Constructivism and Pedagogy

Recent discourse attempts to ground the use of technology in constructivism, which considers how students learn and make meaning of the information presented. Influenced by philosophers and theorists such as Piaget, Dewey and Vygotsky, constructivism emphasizes the subjective aspect of the learning process (Reibel, 1994). From this perspective, much of learning occurs from within the student and the teacher-student dynamic becomes more of a two-way exchange. This self-directed approach to learning also requires interaction and reflection, as students internally process and determine the relevance and applicability of the material presented by the teacher (Strommen and Lincoln, 1992). When they are presented with information, students build upon previous knowledge and construct new understanding.

Students learn better in a constructivist environment because they are mentally and physically engaged in the course material. Critics say that the standard lecture format, which limits students' involvement level, places students in a passive role and values information dissemination over learning. This "banking" approach to teaching assumes that the professor has all the knowledge and the learning process is facilitated when s/he "withdraws" her/his information and "deposits" it in the students' minds (Friere, 1997). By contrast, in a student-centered learning environment, students are viewed as co-constructors of their educational setting. This inclusive approach brings students into the course material, making knowledge meaningful and facilitating learning.

Given the basic tenets of constructivism (i.e. learning is an active, internal, social and contextual process), it would seem that VR could be truly beneficial if it could actively promote the learning process (Gillani, 2000). While some have wondered if this technology is nothing more than a fancy delivery tool, VR's goal is to create an interactive environment

where students can move around and explore aspects related to the virtual world. VR might also promote an atmosphere where students are directly involved with their learning process. For example, students can move around in VR environments to see different vantage points and this information could then build onto their previous knowledge base. In architectural history, perhaps students may see how building space can be experienced differently based on where one moves and stands. With this information, they also may begin to see the influence of one's subjectivity when relating to and experiencing history.

Critical Pedagogy

Aspects of the postmodern perspective, which questions the existence of one grand narrative, provide a theoretical foundation for considering the teaching-learning function. Traditional teaching methods sometimes fail to demonstrate the multiplicity of voices throughout history (in this case, architectural history), and students may be presented with one dominant viewpoint that is often assumed as fact (Foucault, 1990). In following some of the issues raised by postmodernism, there is an acknowledgment of and value placed on the subjective experience (Collins, 1991; Hartsock, 1997). Postmodernism takes a critical examination of how and why specific perspectives emerged and considers different ways to examine the same situation. This reflexive component recognizes that the teacher is not the ultimate purveyor of knowledge and the student perspective becomes crucial in the teaching-learning process. Critical pedagogy also examines the missing and omitted voices in order to get a fuller understanding of the complex and contradictory aspects of the course material (Giroux, 1992). Consequently, a postmodernism pedagogy can be used to expand the interaction between professors and students because it recognizes that the knowledge (interpretation of the course material) is not produced in isolation. In fact, it is the

interchange that occurs between teachers and students that facilitates learning. Perhaps VR can be used to deliver a postmodern pedagogy that will promote a multiplicity of views and to demonstrate the role perception plays in the interpretation of history.

Higher education scholars have discussed ways to make course material more applicable and accessible to an increasingly diverse student population. One of these discussions advocates critical pedagogy as a way to shatter the professor-centered dynamic in the classroom, transforming course material into a powerful, liberating tool that pushes students to become fully engaged (Friere, 1997; Giroux, 1992). In other words, to increase positive learning outcomes, the teaching strategies employed must reflect the varying experiences and viewpoints of the students. When a connection between the student and the course material is made, learning is further enhanced. By acknowledging the validity of their own experiences, VR technology offers students a more authentic educational experience, one that bridges book knowledge and personal knowledge (Wulff, Hanor, and Bulik, 2000).

Research Question

The purpose of this study was to explore how the qualities of VR may impact the way teaching is approached. As this is an emerging area of research, we were somewhat limited in the size and scope of study. Consequently, for this particular investigation, we focused our examination on how the teaching-learning process unfolded in an architectural history course. Our discussion explored on how VR may transform the classroom and the teaching dynamics. Therefore, the following main research question was posed,

How does virtual reality technology affect the teaching-learning process?

Methodology

In order to understand the nuances of the teaching-learning relationship as influenced by the use of VR, qualitative methodology was employed. Such an investigation allowed the researchers to discern how the course instructors interpreted their own efforts to develop critical pedagogy through the inclusion of VR. We used a case study approach because it allowed us to examine some of the issues associated with incorporating VR in a practical setting (Creswell, 1998; Stake, 1998). Case studies also can provide suggestions for future research; it does not attempt to generalize but instead helps others consider the utility of these experiences. This research design revealed the course instructors' experiences and perceptions when they used VR technology as a critical lens to examine Roman architecture.

This section describes the participants and the rationale for selecting them. A description regarding the data collection and analysis process is also presented.

Setting

This study was set at a large, public institution in an urban setting with a diverse student population of close to 37,000. This institution is on the forefront of developing technology that can more directly impact the teaching process. It created a visualization portal, a theatre-style room with a large, spherical screen (160 x 40 degree, 24-foot diameter) that allowed for the projection of computer models and facilitates a more realistic experience of buildings and their structures. The VR images, as displayed in the visualization portal, allowed students to experience architecture in an immersive setting. Three three-gun overhead projectors were capable of overlapping and blending images so that three separate images or a single image could be displayed at once. There were also glasses, which were activated when pointed at the overhead laser sensors that provided a true three-dimensional

view. Movement within the virtual buildings was controlled from a computer room located in the back of the room.

Case selection was determined by the fact this was the first group of instructors at this institution attempting to incorporate virtual reality technology as a critical teaching tool. During the 2001 Winter Quarter, course instructors (one professor and two graduate students) used virtual reality technology to teach architectural history. Specifically, this technology was used to demonstrate, to the 40 enrolled students, aspects of Roman architecture and the class made repeated visits throughout the term to "experience" different building structures, such as the Roman Colosseum.

In moving to a three-dimensional teaching format, the course instructors emphasized the value of an experiential perspective and the emergence of a strong visual sense in students. Additionally, VR was used to demonstrate the cultural and physical influences on a structure's form and purpose as seen through the standpoint of the different people of the Roman era.

Data Collection and Analysis

This study examined how a professor and her two teaching assistants conceptualized and used VR technology to challenge traditional methods of teaching architectural history. In a qualitative case study, research questions were answered through multiple information sources to ensure reliability, avoid misinterpretation, and confirm the various meanings one experience can have on others (Stake, 1998). Classroom and visualization portal session observations were recorded, and a student focus group and individual instructor interviews (see Appendix A-C) were conducted in order to determine how students and instructors experienced and interpreted the virtual reality component. All data were coded for emerging

themes and examined for actions and responses reflecting the use of virtual reality in shaping a more critical perspective of the course material. Themes related to the teaching-learning function were generated at this time.

The literature review helped guide some of the data analysis because it provides some evidence of strengths of VR in relation to this particular case. In this architectural history course, emphasis was on using VR to recreate an alternate reality that provides an immersive experience for the students. This type of interaction, of feeling like one is moving through recreated historical buildings, can provide students with a better perspective of a different time and place and how people move within space (Mitchell, 1995).

Additionally, our exploration of VR focused on its ability to provide a sense of movement within the building structure, reinforce the concept of space and promote diverse cultural perspectives (Sanders, 1997; Siddens, 1999). The use of VR in architectural history might provide students with a more accurate representation of size and dimension. Slide projections often do not portray building scale as effectively and students can end up with a limited perspective of its scope.

Finally, we examined how VR might play an important role in capturing historical and cultural details in order to gain better understanding about building architecture and design. Using this technology, buildings were not presented entirely out of context and students might view design details in relation to the actual structure.

Findings and Discussion

This section focuses on how the inclusion of VR may have affected the teaching-learning process in this one class and, in turn, the instructor and student reactions. As the

informants discussed their experiences, we consider possible implications for the teaching-learning function, and how the use of VR might transform pedagogical practice. The first theme considers how the instructors began to think differently about their teaching style. Specifically, the instructors discussed why they began to approach the course material from a more spatial and experiential perspective. Secondly, VR is used to demonstrate how the history is recreated. In presenting the computer models, students were encouraged to think about history from a more personal, subjective perspective. The third theme focuses on the importance of self-directed learning. Instructors encouraged students to reflect on their VR experiences to create new understanding of the course material.

Teaching Architecture as an Experience

The first theme dealt with how VR technology was used to help reconceptualize how architecture was taught. Historically, architectural history was taught from a two-dimensional perspective, using pictures captured on slides or in books. There were obvious limitations in this approach, especially considering the fact that buildings are three-dimensional structures and pictures only capture one fixed perspective. Thus, VR attempted to capture the three-dimensional quality so that a more complete picture of the building can be presented and discussed (Sanders, 1997). According to the course instructors, the use of VR began to shift their teaching styles as they interacted more directly with the course material. One of the teaching assistants observed,

> I thought [the professor] was saying things that she might not have said [with traditional slide presentations]. I think she was really in tune with the models to the point where she was recalling things to say about the buildings and the spaces because the models were

> invoking that out of her memory. It was almost like the memories of her own knowledge were coming out more smoothly.

The professor concurred with this impression, "I realized I was speaking more about the experiential aspect in lecture, even when the slides were used. Part of the value of virtual reality is that it can push you to think outside of the box [to think more experientially]."

The experiential component that had been difficult to recreate in the classroom setting could be now experienced directly by the students. Data from the focus group suggested that students began to realize the importance of seeing building designs three-dimensionally, envisioning space from multiple perspectives (Mathewson, 1999). One student noted, "It's actually very useful...because we're usually shown [building] plans and you don't really get a sense of how it looks three-dimensionally, so that's really helpful." Another student commented, "We can infer what things look like just by seeing the slides, that's fine, but it [VR] gives you a good idea of the actual dimensions."

Instead of the professor noting the dimensions of a building from a slide projector image, students were presented with a full-version computer model that could demonstrate the scale and scope of the building. Additionally, the class approached the structure from eye-level and had a more realistic view of the interior and exterior. This added feature pushed the students to consider architecture beyond its design elements. As the professor explained,

> I want students to understand the importance of context and that architecture is more than just design. You have to understand [in] architectural culture that design is king. There's the notion that the historical, structural component is less important...and this gets away

from recognizing the validity of your experience in a building.

It appeared that the professor's use of VR attempted to challenge the marginalized status of architectural history and reinforced the relevance of understanding how a building's space is experienced. These perceptions also contributed to the historical understanding of building design beyond just the facts and statistics associated with each historical structure. As the professor noted,

> Usually students are left thinking of buildings in this limited two-dimensional context. As a result, we have architecture design that is limited and unattractive because of how the students are trained. I wanted to integrate this new technology in my course to show students this experiential component [of how] architecture is to be seen as a three-dimensional experience.

By using VR to move the experiential component of architecture to a more prominent place in the course, the interactive aspect to building design was promoted. For example, to understand better a building in its historical context, it was not enough to know its dimensions or construction materials. One must acknowledge the societal context that led to its construction as well as its use (and sometimes destruction). Acknowledgment of this human component (that buildings do not stand alone) can lead to improved building design and use.

In a pedagogical context, VR was being used to expose students to a different perspective of the course material. According to the professor and her teaching assistants, the experiential component, while previously discussed, was relegated to a lesser role when teaching architectural history. For this course, the instructors hoped to use technology to

demonstrate aspects of building structure and design that were less easily explained with two-dimensional images. A teaching assistant spoke of this broadened scope.

> Some of the complexities of architecture that are not easily communicated through slides, not only visual complexities, but contextual complexities, such as the urban situation of a building or even the historical context, the layering of phases for a building through time, I think is better represented to the class using three-dimensional media [so] students would understand the content of architecture better.

Thus, the inclusion of VR was seen to provide additional insight to the course material, pushing beyond the limits of traditional teaching tools. In this case, VR was used to demonstrate the notion that all structures have to be placed in context, not just to study what is there, but why and how it got there in the first place. One student clearly articulated this perspective, "When we went over the Roman Forum, it actually shows which buildings are showing up when and how long they're lasting...what their purposes were and its history. So it brings everything into perspective." Using VR to emphasize the experiential aspect of architecture led to a more complete picture of how buildings existed as a whole and how its various components fit together.

Recreating History

A second finding emphasized the ability of virtual reality technology to demonstrate the subjective nature of history. The computer models were presented as reconstructions based on hypotheses derived from translated texts, artifacts and suppositions. Additionally, the instructors noted that all the computer models recreated the structures at one particular point in time, so that there was a rather limited longitudinal perspective. During our portal

observations, the instructors explained that the recreations were based on the references that managed to survive from that particular historical era. Because many of the structures are currently in ruin, the course instructors noted that no computer model could be 100% accurate.

The instructors attempted to use the VR models as a critical pedagogical tool in demonstrating how the building perspective could be affected by individual movement and use of space. Thus, there was no single fixed perspective that could be accepted as fact. In class lectures, the professor mentioned that one's experience of history was heavily dependent on one's status in society and one's unique perspective would ultimately affect what information gets recorded as fact. When discussing the Roman Colosseum, instructors focused on how one's position in society affected one's sense of building structure. For example, they used VR to demonstrate the upper-class citizens' perspective compared to the lower-class vantage point. Students were asked to consider how the different seating assignments might have led to different experiences and memories about the Colosseum. These multiple views helped reinforce the subjective aspect in architectural history, that building perspectives were dependent on one's level of interaction with it.

Unlike slides, VR images could lead to a critical perspective on how recorded perceptions of buildings were ultimately subjective and open to interpretation. The slide images can appear entirely objective, despite presenting the structures and its details out of context. The VR models allowed these perspectives to be compared because the building was presented in context. In other words, because students could see the entire building at once, sections of the structure could be discussed in relation to each other. For example, in one VR presentation, the instructors demonstrated how different columnar styles radically

affected the appearance of a structure. Instead of showing slides of two structures with different column types, students saw how the Temple of Saturn looked with Corinthian columns and, with a click of the button, how it would appear with Ionic columns. One student commented specifically on this experience, "You could see the Temple of Saturn and you could switch out columns and switch out the architecture. You could see how the proportion existed and how the same building might have looked with alternative borders, which I thought was interesting."

Teaching history from multiple perspectives presented accepted historical fact as relative to an individual's bounded context in time and place (Stanley, 1997). The professor had an assignment that asked students to describe how they would move through the Roman Forum, depending on what their status was during the Roman Era. When reviewing the assignments, one teaching assistant noted, "Two or three students wrote essays that were very geared towards the portal experience and they were clearly reliving it as they were writing. Probably half of the group showed some influence [from the VR experience]." While this comment showed that some students were affected by the VR experience, the effect seemed limited. This limited effect may be because students were not directly asked about historical subjectivity and most were more focused on learning the basic building information. Consequently, despite the instructors' efforts, it was less clear if students actually began to recognize that historical knowledge can be open to examination and critique.

The Self as a Knowledge Source

The final theme examined how VR was used to emphasize notions of the self as a knowledge source. The course instructors used technology to reconceptualize knowledge,

demonstrating how the space experienced by the individual is equally valid to text description and interpretation. This application of constructivism challenged students to rely on themselves as a source of knowledge. The professor explained, "I wanted to encourage students to give their ideas about a building, and I wanted them to synthesize a problem, to look at a building and move through a model. In other words, to use themselves as a source."

To accomplish this goal, students were asked to think about moving through certain building structures on the exams. Could they describe that experience of interacting in a three-dimensional space? What were some key aspects of the building that one would notice? Such questions addressed the internal processing that occurs in learning, by asking students to apply new information to their previous understanding about a particular building design. In some cases, students began to make their own connections to the course material. As one student noted,

> When I wrote the essay for the basilicas, I just envisioned that I was walking in the Basilica Amilia and I could enter it from all the sides. I envisioned it rather then reading in a book. Sure, I read it in the book, but that's what I thought about [the portal experience]. So the [VR] does help, it helps like ingrain it into your memory.

This response demonstrated how this student began to construct his own understanding based on his interaction with the course material. In other words, after seeing the VR model, he used his direct experience to remember key aspects of the basilica. Thus, the student created his own understanding about this structure and did not solely rely on the professor's perspective.

Understanding the VR models ultimately relied on students' own ability to reflect on the information and build upon their previous knowledge. In some instances, this pedagogical approach was a bit of a challenge because many students were not used to thinking in this manner. One of the teaching assistants explained the difficulty some students seemed to encounter.

> I think a lot of students had trouble making the bridge between the portal space and reconstructing this [the buildings] in their own mind in three-dimensional space. They have to take that in and then reconstruct it in their own mind, so they can understand it. I think sometimes the students had trouble understanding where they were in there [when viewing the model in the portal], so they naturally had trouble trying to understand where they were in their own head. I think for most people who were not used to looking at three-dimensional representations of things on a computer screen, it's foreign.

It became difficult for some students to recognize the value of the VR experience because this was a new way of thinking for them, and many were still trying to relate it to the other course information. Besides having to think three-dimensionally, these students seemed comfortable thinking about architectural history from a more removed, third-person perspective. Perhaps this type of thinking originated from the traditional lecture methods that allowed students to adopt a passive role in the teaching-learning process (Strommen and Lincoln, 1992). Therefore, some of these students depended on the course instructors or published material as the main source of knowledge regarding the class material.

The course instructors wanted students to value the subjective because architecture is ultimately an experience based on perceptions of shape and size. In classroom and portal observations, the course instructors used VR to highlight the sense of scale and movement. For example, when moving through the Roman Senate House, the professor approached the VR model at eye-level, so that students could note that the windows were placed extremely high up, suggesting that this structure may not have had a lot of air circulation or natural light. Compared to the slide images, these projections often have more of an eagle-eye perspective, which can lead to discussions on design in addition to the utility and experience of the building. However, some students appeared somewhat resistant to this effort and more comfortable relying on documented sources. As one student explained, "The whole experiential [component], that doesn't teach you a new fact about the building. I could have gotten the same information out of a book."

The course instructors hypothesized that the traditional teaching strategies reinforced the belief that self-knowledge was less relevant and hoped that continued use of VR would challenge this assumption. Learning from this new perspective will not occur instantaneously because students' beliefs about how the learning process should unfold were being challenged. However, the instructors wanted to emphasize that students could use themselves as knowledge sources, just based on their experiences moving through the VR models. Thus, they did not want the students to depend on the instructors for all the course information. In other words, they were trying to shift the traditional teaching-learning paradigm so that less emphasis was placed on the instructors. The hope was that VR could be the medium to help demonstrate that students' perspectives were equally important to the course material, especially given the experiential components in architecture and design.

The constructivist pedagogical approach encourages students to be actively engaged in their own learning process (Reibel, 1994). When the instructors used VR technology to focus on how one experiences the computer models as the main learning tool, the students' hesitation suggested their own lack of confidence and perhaps lack of validation of learning through the self. The professor reflected,

> I noticed students were uncomfortable relying on the self as the source. Again, they seemed to want to have sources to validate their perceptions. The students can't seem to understand the value and weight in saying, if I look down this hall and I think it's boring. They want to have a source that backs up their feelings, but part of architecture is the feeling, the experience of the building.

Perhaps some of these students experienced difficulty because they had to process the information on their own. As long as students continued to rely on the course instructors as the ultimate purveyors of knowledge, it will be difficult for them to be fully engaged in the learning process. VR appeared to more actively demonstrate this dynamic because students were encouraged to interpret their own impressions based on their experiences through the computer models. Active learning required students to process information internally and determine its meaning before full understanding of the material is gained. Otherwise, the traditional teacher-student relationship is left unaltered.

Limitations

This study has several limitations. First, it documents the experience of students and faculty in only a single course taught by one professor and two teaching assistants. As a

result, the sample size is small and findings are preliminary. As this is the first time VR technology was used in this course, some technological difficulties during this first run may have also negatively impacted some of the students' perceptions. As a result, these preliminary findings are limited to the participants in this one course and future research on the effects of VR on the teaching-learning function should include other courses and other instructors. There are opportunities for further research on the effect of VR because this particular study is a continuing one. The stage is set for further investigation because this professor plans on teaching the course again, using VR as a key component.

Another limitation is the fact that the informants in the student focus group are enrolled in the course for very different reasons, depending on whether undergraduate or graduate students. For the graduate students, this course is part of the course requirements while undergraduates enrolled in this course as an elective and as a result, are primarily drawn to the course because of its topic. Consequently, varying student perspectives could have influenced their responses to the VR technology. Those who are required to enroll in this course may have been less open to this approach and, based on their previous exposure to the course topic, have preconceived expectations about how an architectural history class should be taught.

Conclusion and Implications

This study is a first step in determining how VR technology affects instruction and learning. The course instructors use VR to change how architectural history traditionally is taught. By taking a critical pedagogical approach, VR changes the way the course instructors view building design and structure and additional emphasis is placed on the spatial and

physical context. The instructors believe they could more effectively demonstrate the subjective aspect of recorded history along with promoting an understanding of buildings in their context and not just as segmented design pieces.

The instructors also sought to challenge the students' learning process by demonstrating the value of the experiential component to architecture. Some students are comfortable with the greater interaction provided by the computer models and articulated a greater understanding of building's space and scale. The use of VR appears to help them adopt a three-dimensional perspective. The visualization portal sessions seem to push students to discuss their experiences in the virtual buildings, taking into account the structures' purpose and use during a specific era. By constructing their own understanding about buildings, these students are active participants in their own learning process (Oliver, 1997). They no longer only rely on passive sources, such as books and slide projector images.

Integrating virtual reality in the classroom is expensive but individual course costs may go down if implementation is expanded to more classes. Although the instructors indicate that it required many hours to integrate VR into their class, their enthusiasm is noted and valued by many students. The students saw VR's potential but many had not determined its connection to the course information. In this case, instructors may need to be more direct and overt by making the initial connection. These students, being familiar and comfortable with the standard lecture format (especially at a large public institution) might need more prodding to consider their role in co-constructing their learning experience. This process should directly engage students and force them to apply critical thinking skills in order to attain better learning outcomes.

Unlike in the sciences, VR usage is just emerging in the social sciences and humanities (Davis, 1997). As educators begin to assess their efforts incorporating this type of technology, they must also consider how their pedagogy might be influenced by this potential teaching tool. We need to look the technology over time and in multiple settings to see what additional findings and implications may emerge.

Appendix A
Student Focus Group Protocol

1) Let's start by going around the room so that each of you can tell us why you took this course.

2) Okay, let's talk about your learning process in this course.
   a) How helpful were the virtual reality sessions?
   b) Can you give an example of how virtual reality changed the way you think about the course material?
   c) Can you give an example of when virtual reality was a more appropriate method than slides?
   d) Did the virtual reality change the amount of time you had to spend with the course material?
   e) How do you feel about these extra sessions outside of the regular lecture time?

3) How helpful were the slides? Can you give an example of how slides changed the way you think about the course material?

4) How helpful was the web site? Can you give an example of how you used the web site?

5) Okay, let's talk more specifically about your use of virtual reality, the portal sessions. Can you tell me if virtual reality was helpful in completing your assignments? For example, was it helpful on the Roman Forum?

6) Let's move to the material you were presented in these virtual reality sessions. Please answer the following questions thinking of the Temple of Saturn, Roman Forum and Santa Maria Maggiore. Overall, can you comment on whether virtual reality helped contribute to your knowledge of these structures?
   a) How has virtual reality helped you learn about the cultural dynamics surrounding the building development?
   b) How has virtual reality helped you learn about the spatial context to this building's development?
   c) How has virtual reality helped you learn about the experiential context in this structure?
   d) How has virtual reality helped you learn about the chronological evolution of this building's development?

7) Here are some questions that focus more on what you think about virtual reality as a teaching tool. How has virtual reality played a role in your level of interest? How else do you think virtual reality could add to the learning of the course material?

8) What are your overall impressions of the portal sessions?

9) Finally, would you recommend this course to others? Why or why not?

10) Before we end tonight, does anyone have anything to add? Any questions?

Appendix B
Professor Interview Protocol

1) Why were you interested in incorporating VR technology in your course? What was the purpose for incorporating VR technology in your course?

2) How did you anticipate that VR technology would change your pedagogy? Did it?

3) How did the decision to incorporate VR in your course affect the course objectives/goals?

4) Did you perceive any differences between your goals for the course and the students' goals for the course?

5) What helped facilitate the accomplishment of your objectives/goals? What prevented the accomplishment of your objectives/goals?

6) How were the students' progress monitored and evaluated?

7) How did you create assignments that could evaluate the use of VR in your course? What did you learn?

8) How much additional time/people power did it take to incorporate VR into your course?

9) Do you think VR and the web site was able to foster notions of community in the classroom? How can VR be used to foster notions of community in the classroom?

10) We'd like to get your perspective on the student experience. Could you share your feelings about the ability of VR to provide a different perspective on architecture and building design for students in this course?
    a) Did the students seem to understand the spatial and experiential context of buildings when VR was incorporated?
    b) Does the VR seem to promote an expanded perspective of the cultural and physical context of architecture for your students?
    c) Discuss the effectiveness of the use of slides and VR as pedagogical tools.

11) What was the student response to the portal sessions? Discuss the impact the portal sessions had on students' assignments and exams. Did you see a difference in their assignments? In exams?

12) How do you see VR being used in future classes?

13) Anything else to add? Other questions?

Appendix C
Teaching Assistant Interview Protocol

1) Why were you interested in participating in this course?

2) What do you think was the purpose/goal for incorporating VR technology in this course?

3) Can you discuss your interaction with the students? Did VR affect the way you approached your review sessions?

4) How do you think the decision to incorporate VR in the course affected the course goals?
   a) Did you perceive any differences between the professor's goals and the students' goals?
   b) Discuss the role of the course web site in facilitating student learning. Can you discuss the web site and CVR site use to the portal sessions?

5) What aspects of VR (portal sessions, web site) facilitated the accomplishment of the course objectives/goals? What prevented the accomplishment of the course objectives/goals?

6) How did you monitor and evaluate the students' progress? What were the portal session assignments evaluating?

7) Can you quantify the amount of time you put into this course? What specific tasks were involved?

8) Do you think VR and the web site was able to foster notions of community in the classroom? How can VR be used to foster notions of community in the classroom?

9) We'd like to get your perspective on the student experience. Could you share your feelings about the ability of VR to provide a different perspective on architecture and building design for students in this course?
   a) Did the students seem to understand the spatial and experiential context of buildings when VR was incorporated?
   b) Does the VR seem to promote an expanded perspective of the cultural and physical context of architecture for your students?

10) Discuss the effectiveness of the use of slides and VR as pedagogical tools.

11) What was the student response to the portal sessions?

12) Discuss the impact the portal sessions had on students' assignments and exams. What were the portal session assignments evaluating? Did you see a difference in their assignments?

13) How do you see VR being used in future classes?

14) Anything else to add? Other questions?

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